

THE ORIGIN OF A LIMESTONE ROCK¹

IN November, 1845, I laid before the Literary and Philosophical Society of Manchester my memoir "On some Microscopic Objects found in the Mud of the Levant and other Deposits; with Remarks on the Mode of Formation of Calcareous and Infusorial Siliceous Rocks," which memoir was published in vol. viii. of the second series of the Society's *Transactions*. In that memoir I sought to demonstrate two things—1st, that not only was Chalk made up of microscopic organisms, chiefly Foraminifera, as had recently been demonstrated by Ehrenberg, but that the fact was equally true and explanatory of the origin of all limestones except a few freshwater Travertins; 2nd, that some other extensive deposits, of submarine origin, in which no Foraminifera could now be detected, were not in the state in which they were originally accumulated. I concluded that Foraminifera had doubtless been present in them also, but that their calcareous shells had been dissolved out of them, and that this disappearance had been effected through the agency of water containing carbonic acid, at an early stage of the formation of these deposits. As is well known, this latter theory has been reproduced as a new one by some of the naturalists of the *Challenger* expedition, who have applied it to the explanation of phenomena of a substantially similar nature to those which I endeavoured to account for, in the same way, more than thirty years previously.

I am indebted for the slab of limestone forming the subject of this communication to my friends the Messrs. Patteson, the marble merchants of Oxford Street, Manchester. This slab appears to illustrate in an exquisite manner both the theories to which I have just referred. It is a specimen of the Bolland limestone, which, when sawn through, was found to contain a large concamerated Nautiloid shell more than twelve inches in diameter, which appears to me to have been a true Nautilus, though the section has not passed exactly through its centre so as to reveal any portion of its siphuncle. In the various parts of this slab we find the calcareous material exhibiting different conditions. Throughout the greater part of its substance we have evidence that it has originated in an accumulation of minute calcareous organisms—especially Foraminifera—but most of these are disintegrated and display vague outlines, a condition which I presume has resulted from the action of the carbonic acid already alluded to.

Scattered through the slab are numerous dark-coloured patches of a substance apparently identical with what the late Dr. Mantell designated Molluskite, and which he believed to be the remains of the soft animal substance of marine organisms. In many of these patches the Foraminiferous shells are better preserved than is the case with the rest of the matrix inclosing the large fossil shell. It appears as if this Molluskite had partially protected the calcareous Foraminifera from the solvent action which had disintegrated most of those forming the rest of the deposit.

But the most interesting features of the specimen are seen within the chambers of the Nautiloid shell. The Foraminiferous ooze has entered freely through the large, open mouth of the terminal chamber in which the animal resided and filled the entire cavity of that chamber. There is no doubt whatever as to the original identity in the character of the ooze thus inclosed within the shell and that which constitutes its investing matrix, though they now appear very different. The latter portion was freely permeated by water containing the solvent carbonic acid; hence the more or less complete disintegration of its Foraminiferous shells. But in the limestone inclosed

within the large terminal chamber of the Nautiloid shell almost every Foraminifer is preserved in the most exquisite perfection. This is especially the case in the deeper part of the chamber, most remote from the mouth, as also in the instances of one or two of the more internal closed chambers, into which the mud has obtained entrance through small accidental fractures in the outer shellwall. It appears obvious to me that the thick calcareous shell of the Nautilus has protected the inclosed shells of the Foraminifera from the action of the solvent acid. I repeat that there is no room whatever for doubting that both portions of the Foraminiferous ooze, whether contained within or surrounding the Nautiloid shell, were originally in identical states. Microscopic observation makes this sufficiently plain. The differences now observable between them have arisen from changes which have taken place subsequent to their primary accumulation, and which changes have been due to differences of position; the one portion has been protected by the thick calcareous Nautiloid shell which would rob the water percolating through it of all its solvent carbonic acid, and thus preserve the contained Protozoa from destruction, and which protection would continue so long as any portion of the Nautiloid shellwall remained undissolved. The other, being unprotected, would be exposed to the full action of the solvent, which would percolate readily amongst the loosely aggregated microscopic organisms, and speedily act upon their fragile shells.

But there is a yet further feature in this interesting specimen requiring notice. The closed chambers of the Nautiloid shell are all filled with clear, crystalline, calcareous spar. The acidulated water, acting upon the calcareous Foraminifera of the ooze has become converted into a more or less saturated solution of carbonate of lime. This has passed, by percolation, through the shell of the Nautilus into its hollow chambers. Finding there suitable cavities it has gradually filled them up with a crystalline formation of calcareous spar, and which of course exhibits no traces of the minute organisms from which the calcareous matter was primarily derived. A similar crystallisation has filled up the smaller interspaces between the Foraminiferous atoms both inclosed within, and external to, the Nautilus, rendering the limestone capable of receiving a high polish.

If these explanations are as correct as I believe them to be, we have here the entire history of the origin of a limestone rock—from the first accumulation of the Foraminiferous ooze, as seen in the interior of the first large chamber of the Nautilus, to the deposition, in an inorganic mineral form, of the crystallised carbonate of lime within the closed chambers of the Nautilus, all being illustrated within the area of a slab of limestone little more than a foot in diameter.

THE LIQUEFACTION OF THE GASES

IN the recent article, in which the magnificent results recently obtained by MM. Cailletet and Pictet were detailed, we contented ourselves, in the account of the methods employed, by pointing out the extreme simplicity of that used by M. Cailletet. The simplicity, however, by no means takes away from the beauty of the method, and we now propose to return to it with a view of showing how closely it resembles in many of its details that employed by Dr. Andrews in his classical work on the continuity of the various states of matter.

Dr. Andrews, it will be remembered, in his experiments on the liquefaction of carbonic acid, used a glass tube capillary in the upper part, and in the remainder, of a bore just so wide that a column of mercury would remain in it when the tube was held in a vertical position. The gas to be operated on was confined to the narrow upper part of the tube by mercury, and the tube was tightly packed to an end piece of brass armed with a flange.

¹ "On the Microscopic Conditions of a Slab from the Mountain Limestone of Bolland," by W. C. Williamson, F.R.S., Professor of Natural History in Owens College. Read before the Literary and Philosophical Society of Manchester, January 8.

This permitted a water-tight junction with a corresponding end of a cold-drawn tube of copper of great strength. A similar end-piece was attached to the other extremity of this

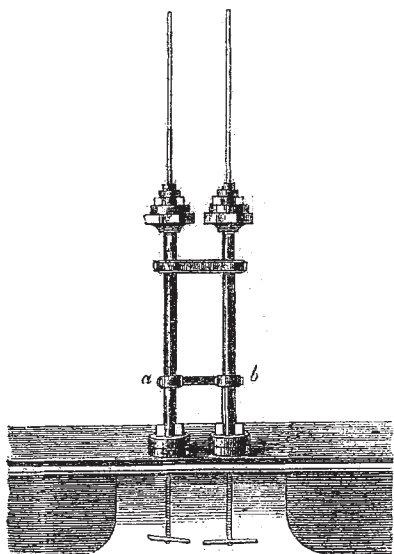


FIG. 1.—Two of Dr. Andrews's tubes on a stand as in use.

copper cylinder, and in the centre was a fine screw most carefully made and fitted, seven inches long, and packed so as to resist a pressure of 400 atmospheres or more.

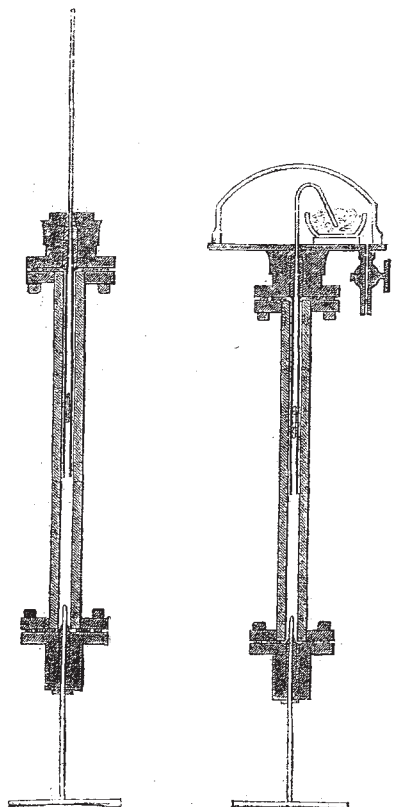


FIG. 2.—Section of Tube. FIG. 3.—Arrangements for Utilising Low Temperatures.

When low temperatures as well as high pressures were required, the tube was bent, as shown in Fig. 3, and inserted in a freezing mixture.

In all these tubes the pressure is produced by screwing up the mercury into the capillary tube.

We have next to consider the phenomena which Dr. Andrews observed, taking carbonic acid as an example.

On partially liquefying the gas by pressure and changing the temperature, the surface of demarcation between the liquid and the gas became less and less distinguishable, the tube seemed to be filled with a homogeneous fluid which, when the pressure was suddenly diminished, or the temperature slightly lowered, broke up into striæ, Fig. 4.

A cloud was also formed if the temperature were allowed to fall a little below the "critical point" $30^{\circ}92$ C., showing the formation of liquid particles, Fig. 5.

We may now pass to M. Cailletet's method and the phenomena he observes, Fig. 6, for which we are indebted to the courtesy of the editor of *La Nature*, represents the great apparatus which M. Cailletet has constructed at his works of Châtillon-sur-Seine.

The apparatus is composed of a hollow steel cylinder A solidly fixed to a cast-iron frame by means of the hoops B B. A cylindrical shaft of soft steel acting the part of a plunger enters this cylinder, which is filled with water. The opposite extremity of the shaft is

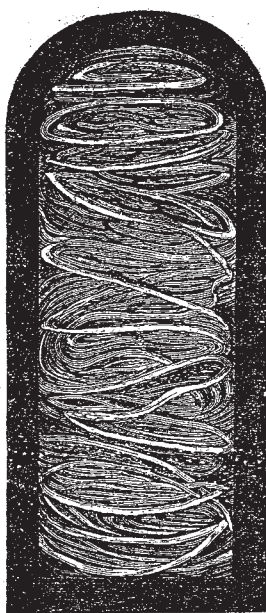


FIG. 4.—Striæ.

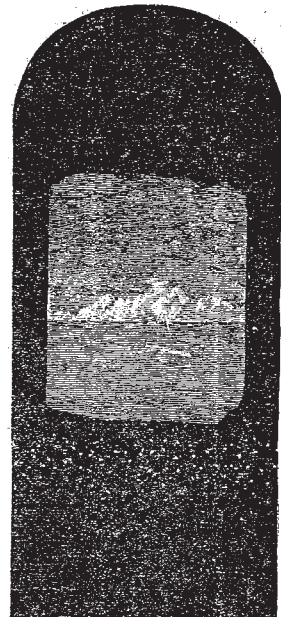
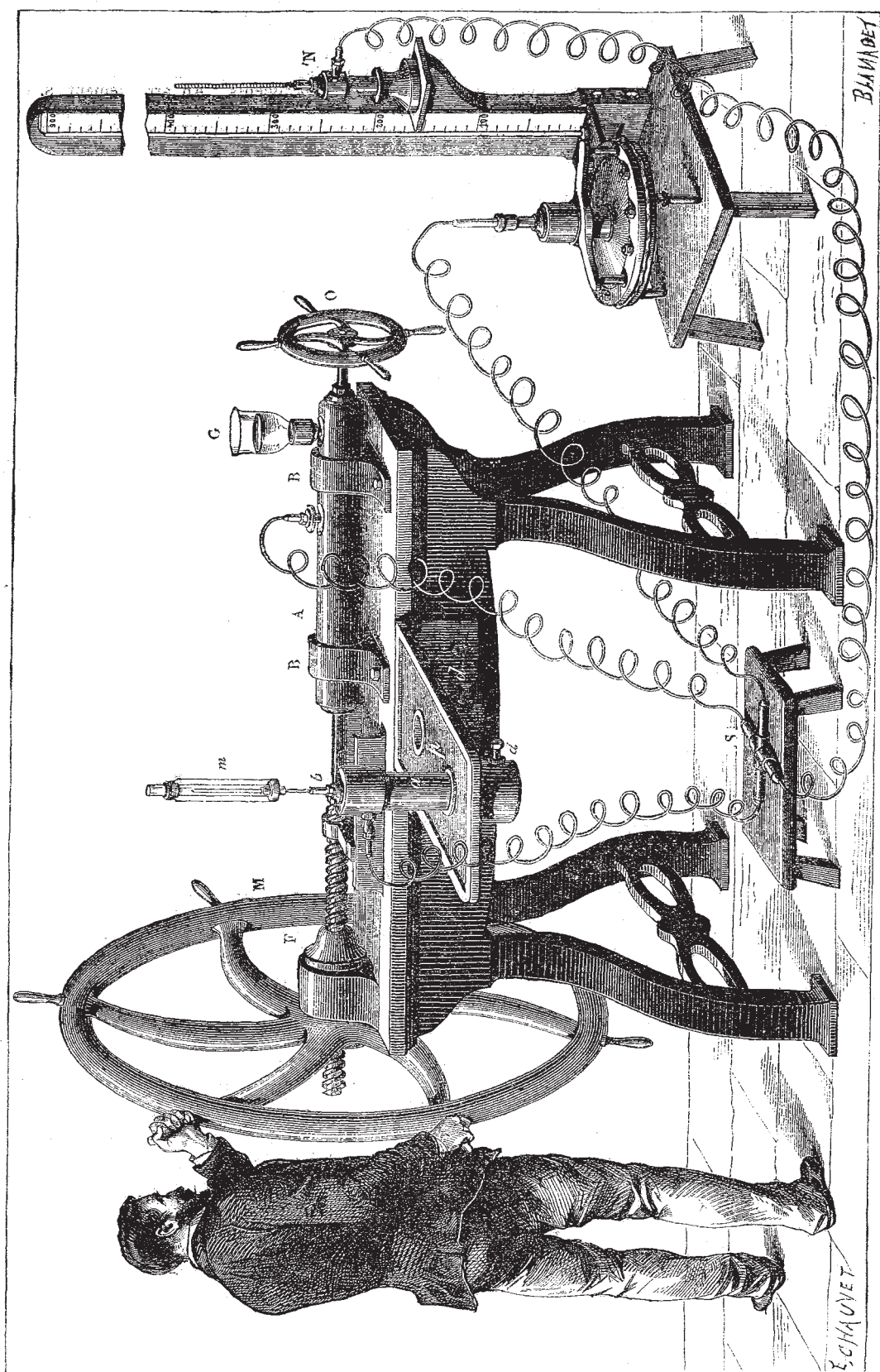


FIG. 5.—Cloud.

terminated by a square-threaded screw, which traverses the bronze nut F, fixed in the centre of the fly-wheel M. According to the direction given to the fly-wheel by means of the handles with which it is provided, the plunger may be advanced into or withdrawn from the axis of the body of the pump. A leather packing prevents the compressed liquid from escaping from the cylinder.

In order to introduce the water or the liquid to be compressed, it is poured into the glass vessel G, which is in communication with the interior of the apparatus; a steel screw with conical point closes the narrow pipe through which the liquid passes. This screw is terminated by a small fly-wheel O, with handles. This arrangement permits of suddenly expanding the compressed gases, and seeing the cloud produced in the capillary tube where the gas under experiment is contained. (This tube is represented in the centre of the glass envelope, *m*.) The cloud is formed under the influence of the external cold produced by the sudden expansion, a certain sign of the liquefaction or even of the solidification of the gases regarded hitherto as permanent. *a* is a hollow steel reservoir



capable of supporting a pressure of from 900 to 1,000 atmospheres; it is connected with the compression apparatus by a capillary metallic tube. The water, under the action of the piston, arrives in this reservoir, *a*, and acts upon the mercury which compresses the gas. *b* represents the tube which connects this with the glass intended to contain the gas under experiment. A nut serves to fix this piece to the upper part of the reservoir. Fig. 7 shows this arrangement in half-size.

m is a glass cover containing a cylinder of the same material, in the middle of which is a small tube in which the liquefaction of the gas takes place. This capillary tube may be surrounded with refrigerating mixtures or with liquid protoxide of nitrogen. The exterior cover, *m*, concentric with the first, and containing substances strongly

absorbent of moisture, prevents the deposit of ice or vapour on the cooled tube in which the experiments are made. *p* is a cast-iron tablet intended to support the reservoir, *a*; the screws, *d d*, enable the reservoir to be raised or lowered for the spectroscopic examination or the projection of the experiments. An arrangement, *s*, unites the capillary metallic tubes which transmit the pressure to the various parts of the apparatus. *N* is a modified Thomasset manometer verified by means of an air manometer established on the side of a hill near the laboratory of Châtillon-sur-Seine. *N'* represents a glass manometer which serves to control the indications of the mercury apparatus.

It is a fortunate thing that the students of science in

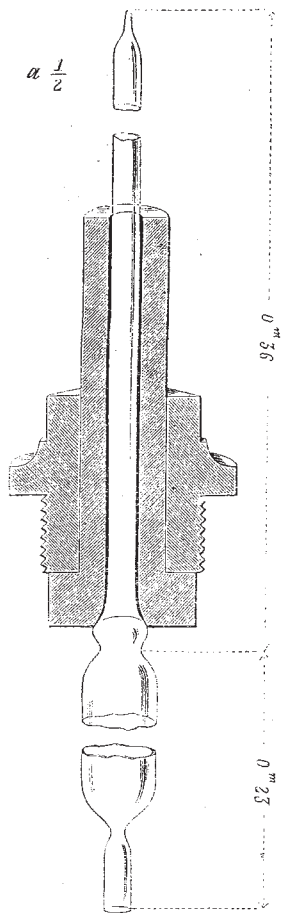


FIG. 7.

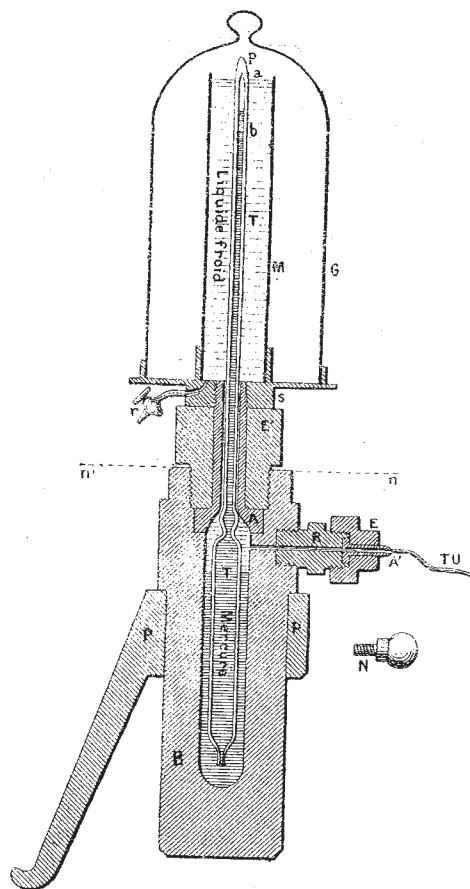


FIG. 8.

FIG. 7.—Glass tube with thick sides in which the liquefaction of the gases is effected in M. Cailletet's apparatus. The gas is compressed in the upper part of the tube by the ascent of a column of mercury placed in connection with a screw-press acting on a mass of water. It condenses in a liquid drop or into mist under the action of expansion. This glass tube is enveloped in an envelope of the same substance containing the refrigerating mixture. See the centre of the tube *m* in Fig. 2. FIG. 8.—Small apparatus for the liquefaction of gases.

France have not been forgotten by M. Cailletet. He has not only devised the instrument above described for his own work, but he has occupied himself with a small lecture or laboratory apparatus which M. Ducretet has constructed according to his directions. It is an exact copy of the part, *a, b, m* of the apparatus of Châtillon-sur-Seine. The bell-glass alone is modified. The screw-press is, moreover, replaced by an easily-worked pump. In Fig. 8 *r' r* is a glass tube filled with the gas to be compressed; the tube has been traversed by the gas until air has been entirely excluded; for this purpose it is placed in a horizontal position. When it is

filled with the gas to be experimented on it is hermetically sealed at its extremity, *p*, closed with the finger at the other end, and introduced vertically into the iron apparatus as represented in the figure. It is inserted into a cylindrical cistern containing mercury. The upper part of the tube is enveloped in a glass envelope, *M*, filled with a refrigerating mixture. The whole is enveloped in a glass jar, *G*. The tube, *TU* is connected with a compressing pump, which is worked with the hand. The water compressed by the pump acts on the upper part of the mercury indicated in the figure by horizontal lines. This mercury is driven back into the

tube TT; it reduces the space ab occupied by the gas, and is soon surmounted by droplets of the compressed gas, which unite into a little mass of liquid, b .

The following are the parts of the apparatus:—B, a block of malleable iron with strongly-resisting walls; E, E, screw nuts which may be unscrewed to arrange the apparatus before using it; PP, very solid tripod which receives the apparatus; S, support of the bell G and the envelope M; N supplementary screw intended to close the hole in the joint R when the mercury is poured into the apparatus.

OUR ASTRONOMICAL COLUMN

THE ROYAL OBSERVATORY, CAPE OF GOOD HOPE.—Since the appointment of Mr. Stone to the directorship of this establishment, in 1870, not only have all arrears of observations with the transit-circle, first brought into use in 1855, been reduced and published, but Mr. Stone has lately issued the results of observations taken in 1875, and has thereby overtaken the position of publications of the Royal Observatory, Greenwich, and the Radcliffe Observatory, Oxford, which have been conspicuous amongst astronomical establishments for the expedition with which the great mass of work involved in the reduction of the observations has been performed, and the results given to the scientific public.

The chief work of the year was the continuation of the general re-observation of the stars in the *Cælum Australe Stelliferum* of Lacaille, attention in 1875 having been directed to those stars lying between 145° and 155° of north polar distance at the present epoch, all of which appear to have been observed, usually three times in both elements, together with a number of other stars in the same zone, which, though not generally much below the seventh magnitude, were not observed by Lacaille. Mr. Stone mentions that stars within limits of N.P.D. 135° – 145° were observed in 1876, and stars between 125° – 135° in 1877.

Should it be deemed advisable shortly to form another general catalogue of stars, similar to the British Association Catalogue, say to stars of the seventh magnitude inclusive, Mr. Stone's recent volumes will be of the utmost value in extending the precision now attainable for such stars in the northern hemisphere to the southern heavens, not only as regards positions for the present epoch, but in the determination of proper motions of a considerable number of stars by comparison with Taylor's catalogues, which have not yet been systematically examined for that purpose. And we will take this opportunity of expressing the hope that if another catalogue like the B.A.C. should be undertaken, the time, labour, and expense involved in the preparation of so-called star-constants may be avoided, and attention paid instead to a more general and systematic investigation of proper motions, which, it can hardly be doubted, must lead to results of great interest and importance.

THE TOTAL SOLAR ECLIPSE OF JULY 29.—It was mentioned in NATURE last week that facilities would be afforded to intending observers of this phenomenon near Denver, Colorado, one of the chief places included in the belt of totality in the United States, and situated on the Pacific line of railway. By the elements of the *Nautical Almanac* the track of central eclipse appears to pass about twenty-five miles south of Denver, assuming its longitude from Greenwich to be 7h. om. 20s. W., and latitude $39^\circ 48'$, and at Denver the total phase commences at 3h. 28m. 14s. local mean time, and continues 2m. 45s., with the sun at an altitude of 42° ; the circumstances by the elements of the American ephemeris are almost identical, as indeed was to be expected seeing that the moon's place in the latter work differs from her place in the *Nautical Almanac* by only $+3''.4$ in R.A. and $+1''.0$ in decl. and the sun's place by $-1''.1$ in R.A. and $+0''.3$ in

decl., while the semi-diameters employed are each less by about $2''$. In the American ephemeris the lunar tables of Peirce and the solar tables of Hansen are employed.

The northern and southern limits of totality in the eclipse of July 29, with the duration of total phase upon the central line, for nearly the whole track across the North American continent will be found at p. 400 of the *Nautical Almanac* for 1878.

CHEMICAL NOTES

TEMPERATURE OF FLAMES.—In the *Gazetta chimica Italiana* an account is given by F. Rosetti of some experiments on the above subject. To examine the temperatures he employs a thermo-electric element consisting of an iron and a platinum wire wound closely together and connected with a galvanometer. This latter was graduated to various temperatures by observing the deviation consequent on bringing the element in contact with a copper cylinder heated to known temperatures; these being determined by introducing the cylinder into a calorimeter. With such an arrangement he has investigated the flame of a Bunsen's burner, finding that in the same horizontal strata there were but slight alterations in the temperature, with the exception of the dark interior portion. Thus, where the external envelope showed $1,350^\circ$, the violet portion of the flame was $1,250^\circ$, the blue $1,200^\circ$, but the internal portion much lower, its temperature gradually decreasing from the base of the flame upwards. A flame produced by the combustion of a mixture of two volumes of illuminating gas and three volumes of carbonic oxide, showed a temperature of $1,000^\circ$.

STARCH IN PLANTS.—Botanists have hitherto held that all the starch in the chlorophyll cells of the leaves of plants is a product of the direct assimilation of carbon dioxide and water, basing this belief on the fact that the starch in these cells disappears when the plants are deprived of the power of assimilating carbon dioxide, but reappears on their exposure to light in an atmosphere containing that substance. Prof. Bohn, of Vienna, in a recent number of the *Deut. chem. Ber.*; throws some doubt on this conclusion by experiments he has made on the leaves of the scarlet runner. His results show that if the primordial leaves of this plant are shaded from light, the starch at first entirely disappears; after a few weeks, however, the chlorophyll cells of these shaded leaves show almost as high a percentage of starch as the parts of the plant which have been exposed to light. These observations demonstrate, therefore, that starch can be formed in the leaves from matter which has already been assimilated, and has entered into the leaf after its removal from the sunlight.

SIPYLITE, A NEW MINERAL CONTAINING NIOBIUM.—Mr. Mallet has found this mineral among some quantities of allanite from Amhurst county, Virginia. A few crystals have been obtained, but as they are of rather imperfect nature the measurement of the angles has only been attempted in a rough manner. The mineral in the mass was of a brownish black nature, but in thin plates it exhibited a reddish-brown colour, and possesses a pseudo-metallic lustre. The hardness is estimated at about 6, and the specific gravity as equal to 4.89. From the results of analyses Mr. Mallet considers that placing together the acid oxides of niobium, tantalum, tungsten, tin, and zirconium, reducing the basic oxides to equivalent amounts of dyad oxides, and eliminating the water, the following ratio may be obtained:— $R''O : M''_2O_3 = 221 : 100$, leading to the formula $R'_3M''_2O_8 \cdot 4R''_2M''_2O_7$, that is a single group of orthoniobate associated with four of pyroniobate. If the water be taken into account in the calculation and considered basic, then placing it on the same footing as the dyad oxides, we should have the